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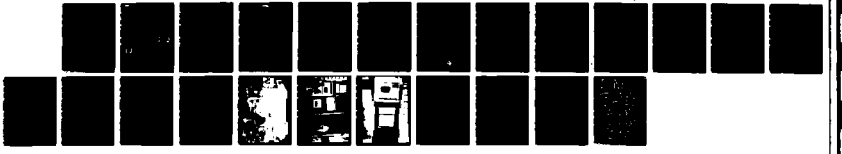

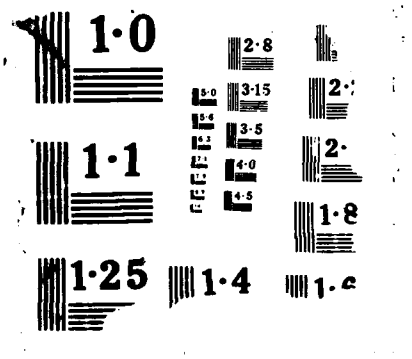
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TECHNICAL REPORT ARCCB-TR-88008

COMPUTER INTEGRATED MANUFACTURING FOR CANNON

A. WAKULENKO

FEBRUARY 1988

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4. TITLE (and Subtitle) COMPUTER INTEGRATED MANUFACTURING FOR CANNON		5. TYPE OF REPORT & PERIOD COVERED Final 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) A. Wakulenko		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS US Army ARDEC Benet Laboratories, SMCAR-CCB-TL Watervliet, NY 12189-4050		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS AMCMS No. 6126.23.1BL0.0 PRON No. 1A-7-2RZWV-NMSC
11. CONTROLLING OFFICE NAME AND ADDRESS US Army ARDEC Close Combat Armaments Center Picatinny Arsenal, NJ 07806-5000		12. REPORT DATE February 1988 13. NUMBER OF PAGES 14
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer Integrated Manufacturing,
Distributed Numerical Control,
Computer Numerical Control,
Retrofit

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains the results of one segment of a Computer Integrated Manufacturing (CIM) program for cannon under the Manufacturing Methods and Technology program. This portion of the CIM program addresses the expansion of Watervliet Arsenal's CIM system, operating under Distributed Numerical Control, with early generation numerical control machine tools. Project activities concentrated on the integration feasibility of old inventory

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20. ABSTRACT (CONT'D)

numerical control machines and the current computer numerical control technology to determine the viability of retrofitting a state-of-the-art control to an older numerical control machine for direct Distributed Numerical Control communication. Based on this investigation, a numerical control machine tool was remanufactured and connected to Watervliet Arsenal's Distributed Numerical Control system.

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BACKGROUND AND INTRODUCTION

This report covers one segment of Watervliet Arsenal's Computer Integrated Manufacturing (CIM) program and assumes that (References 1-3) CIM and Distributed Numerical Control (DNC) technology are understood. In-depth information on the other (Reference 4) CIM projects conducted at Watervliet will be addressed in other individual reports and will not be elaborated on herein.

The acquisition of Watervliet Arsenal's pilot Distributed Numerical Control (DNC) system raised the question: can the Arsenal's early generation numerical control (NC) machines become part of this DNC network? These early NC machines do not have controls modern enough to allow them to be interfaced to the DNC system, nor new enough to justify their use in Watervliet's overall CIM system.

CIM and DNC are part of the Arsenal's major modernization accomplishments. Included were the acquisition of numerous new, state-of-the-art computer numerical control (CNC) machine tools to replace and supplement the Arsenal's existing machine tool inventory. A large number of machines that were replaced and those still in use were early generation NC and CNC machines which, by virtue of their control, had no place in Watervliet Arsenal's factory automation goals. However, the potential did exist to include these machines in the CIM system via this project.

Two major outcomes were anticipated. The first was that outdated numerical control machines in good condition could be put back into service economically, and secondly, a state-of-the-art control that would communicate directly with Watervliet's DNC network would be identified.

References are listed at the end of this report

PROBLEM

Watervliet Arsenal's current CIM program was not initially designed to address the inclusion of outdated, early generation NC machines. Therefore, a void is created because the Arsenal, as well as most other government manufacturing facilities, has a considerable amount of older equipment still operating in production.

PROBLEM APPROACH

The approach this project took was to determine the integration feasibility of the Arsenal's old inventory of NC machines to the current DNC network. This included the analysis of the variety of original equipment manufacturer's (OEM) controls to diagnose their degree of obsolescence and/or application to DNC. Also analyzed was the current CNC control technology to determine the viability of retrofitting a state-of-the-art control to an Arsenal NC machine for direct DNC communication. Based on this research, an NC machine tool was remanufactured and connected to Watervliet's DNC system.

SOLUTION TO THE PROBLEM

An evaluation of the Arsenal's early NC machine tool population revealed that some of these machines have controls that could be connected to the Arsenal's DNC network. This would involve the addition of a proprietary Machine Interface Unit (MIU) to each existing machine control. The installation of a MIU is the same way Watervliet Arsenal interfaced six machines to their current pilot DNC system.

This approach, although logical, did have a serious drawback. The MIU is a proprietary item manufactured by the Arsenal's DNC supplier and therefore, a sole source procurement was inevitable. Secondly, by using these MIUs, the Arsenal is locked into a single, dedicated and limited way of connecting additional equipment to its DNC network. This causes complete reliance on one manufacturer for parts, service, and any expansion goals.

The simple addition of an MIU was not all that was needed to be accomplished in order to incorporate early generation NC equipment into the Arsenal's DNC. Since these machines have been used in production manufacturing, they basically are worn and could use extensive rebuild. From the standpoint of efficiency and economy, these machines must be retrofitted with a new up-to-date CNC unit and rebuilt mechanically to upgrade them to a new machine status. The aforementioned still would not solve the problem of sole sourcing an MIU once an older machine tool is remanufactured. The problem is that DNC features are designed around each manufacturer's own communication protocol, whereby, if a manufacturer designs and builds a DNC system for a customer, the builder's own CNC is essentially plug-in-ready to their DNC. However, if the DNC system is made by another manufacturer, a special interface still must be designed to allow compatibility with the communication protocol resident in that DNC system. At this point in the project, DNC communication technology is not standardized to be compatible (without special interfacing) with one manufacturer to another.

Regardless of what type of interfacing is needed, it was concluded that DNC is possible from the standpoint of this project. The question that will be answered is whether a control builder or a retrofitter will be able or willing

to take an appropriate control and produce the necessary interfacing to successfully link a new CNC and a machine to Watervliet Arsenal's DNC network. It was anticipated that there were a number of ways this task would be addressed, and the simplest way was to have the Arsenal's DNC OEM perform the retrofit with their control or MIU. However, this approach would not prove that other control manufacturers can do the same with their own equipment and would somewhat support a sole source situation even though a contract will be a competitive procurement activity. Ideally, to meet this project's objectives, it would be advantageous and preferable to have the retrofit task accomplished by an independent contractor, and have a different manufacturer's CNC and interface connected to the Arsenal's DNC system. There was a possibility that a contractor (not OEM) would purchase an OEM control or MIU or both and complete the required retrofit task as necessary. This situation would still prove that the first and subsequent DNC retrofit efforts can be performed by contractors other than the DNC system OEM.

RESULTS

As a result of the foregoing, a specification (LCB-SE-6-84) was written to have an Arsenal 5-axis K&T machining center, Figure 1, reconditioned and retrofitted with an appropriate CNC and be made plug-in compatible with Watervliet's DNC system. Since the condition of the 5-axis machine was listed as "very good", rehab to the machine surfaces or parts that did not impact on the computer retrofit was not anticipated. Therefore, the specification was prepared to have a contractor concentrate primarily on the CNC and DNC retrofit and secondly, evaluate the machine mechanically. If determined that any portion

of the machine needed rehab, a negotiation avenue was included to have the contractor make the necessary corrections and be compensated accordingly.

Procurement actions yielded four proposals of which three were evaluated to be acceptable offers. The DNC integration issue was addressed by each offeror differently. One offeror proposed an entirely non-OEM package (CNC and DNC interface). Another offeror proposed two avenues, either an entirely non-OEM system or a non-OEM CNC and an OEM machine interface unit pending further investigation into the proprietary communication protocol data. The third offeror decided to retrofit an entire OEM package. The reason for the various responses was that the responsibility of obtaining the technical information on Watervliet's DNC communication protocol from the DNC builder rested with the offerors. This was mandated because the government did not have the liberty to distribute the proprietary information nor had they access to it at the time. However, all three proposals complied with all the DNC interface requirements and the offerors were aware of the obligation to provide it once under contract. Finally, none of the three proposals were from the OEM of the Arsenal's DNC.

In September 1986, a contract was awarded to Kearney & Trecker (K&T) Corporation to perform the retrofit service. K&T, after being unable to negotiate access to the pertinent proprietary information from the DNC builder, decided to retrofit their own KT-GEMINI-D control (CNC), Figure 2, and use the OEM, White Sundstrand (WCI), SL2BTR DNC unit (MIU), Figure 3. Without access to WCI's DNC communication protocol, K&T decided that it would be cost prohibitive to attempt to engineer their own DNC interface to WCI's host computer. Although this approach was not the most preferred method, it was still a breakthrough

because sole sourcing (via the government) the DNC interface was eliminated. This contract has proven that it is possible to put additional machines on-line with Watervliet Arsenal's DNC without going directly to WCI, the DNC original equipment manufacturer.

Figure 1 shows the 1972 K&T 5-axis machining center currently implemented and manufacturing 120mm cannon breech mechanism components. This machine, once installed and tested, has operated in production manufacturing since July 1986 as a stand-alone machine programmed via the CNC's tape reader input (Figure 2). In December 1986 the DNC unit or machine interface unit, Figure 3, was connected and from that point on, the machine has been operating under DNC accepting part programs from a remote DNC host computer located in an entirely different building. Prior to this project the K&T machine had been taken out of service for obsolescence and destined to be excessed. The machine's original CNC was the prime reason for obsoleting the machine initially.

CONCLUSIONS

Based on this investigation, certain lessons were learned. First, the Arsenal is not locked into a sole source procurement situation when it comes to ordering CNC units or CNC machine tools with DNC communication provisions. Therefore, it is possible for the Arsenal to specify that any or all CNC machine tools be provided with their own DNC interface, whether the interface is OEM or custom designed. The burden falls on the machine tool builder to provide whatever is necessary to accommodate the Arsenal's DNC system requirements. Another important lesson learned is that any generation machine can be connected to the DNC network without, again, relying on the DNC original equipment manufacturer as a sole source. The K&T contract has proven that an independent

contractor can and is willing to assume the DNC interface responsibility. The only drawback is that the added responsibility comes with a premium price tag, wherein the contractor must pay a higher price for an OEM DNC interface and charge additional fees to engineer its inclusion and to guarantee its performance.

Though this project addressed early generation numerical control equipment, the results impacted directly on the plans to expand the pilot DNC system with Watervliet's new or newer CNC equipment. The WCI machine interface unit proved to be the primary concern or obstacle when decisions were made to expand the six machine DNC pilot line. Consequently, Watervliet decided to enhance its DNC plans by revamping the original DNC system with standard computer hardware and operating systems to eliminate the dependance on the WCI machine interface units. Interfacing will be handled by way of standard software and simplified interface hardware requirements which will not impact on proprietary channels. Included in this revision will be the compatibility of communication to a Local Area Network (LAN) which manages the entire factory NC program database.

Currently, Watervliet Arsenal is in the process of expanding its pilot DNC system with a plant-wide implementation of over 200 machines (including the K&T machine). The plant-wide system plans will combine the technologies of DNC and factory LAN to institute a three-level communication architecture with the LAN providing the primary communication means among the three levels.

Quantifiable benefits anticipated from the DNC communicating machine should save as much as $7,330 annually (Table I). This is based on projections made in the overall CIM technology program. Additionally, it is estimated that 60% of a new equipment acquisition cost was saved. The K&T contract was for $322,000 and

if a comparable new machine was purchased, an estimated additional $483,000 would have been required. Therefore, for 40% of the cost of a new machine the Arsenal has an implemented, up-to-date production machining center operating effectively under DNC. Furthermore, once the Arsenal's new DNC network is implemented, the same quantifiable savings should continue to be realized.

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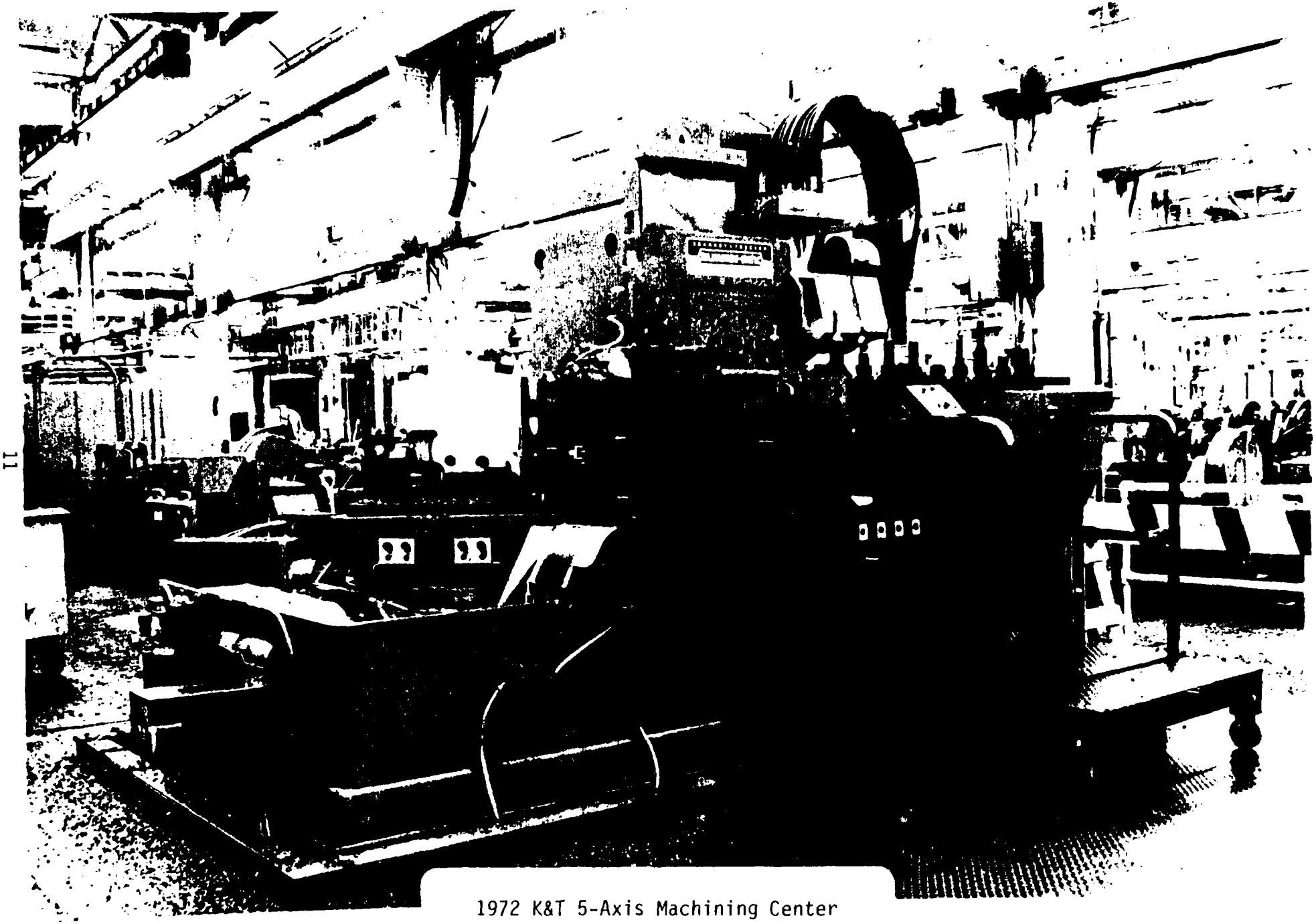
TABLE I

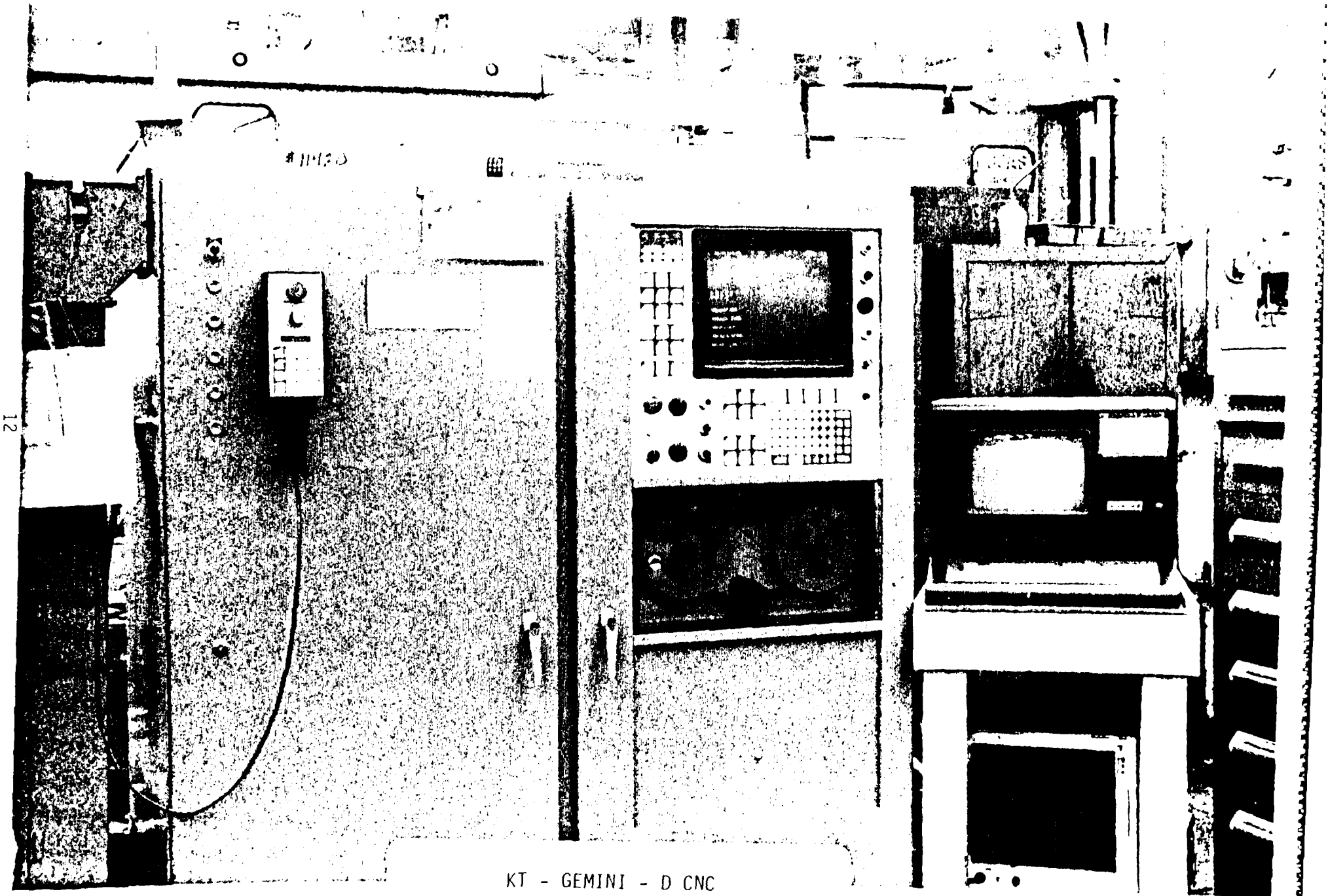
ANNUAL QUANTIFIABLE SAVINGS

	BENEFIT	SAVINGS (hrs)	$ AMOUNT
1.	Tape reader load and unload time eliminated.	176 hrs./yr.	$ 2338.
2.	Routine operator preventative maintenance eliminated.	90 hrs./yr.	1260.
3.	Maintenance and/or repair of tape reader.	25 hrs./yr.	326.
4.	Increased shop efficiency through status and utilization reports.	140 hrs./yr.	1960.
5.	Increased repair response to breakdown of machine or control.	30 hrs./yr.	420.
6.	Improved direction of machine operator.	40 hrs./yr.	560.
7.	Savings in tape supplies and equipment.		98.
8.	Reduction in scrap (reader errors for example). 5% of scrap history.		368.
	Total Annual Savings		$ 7330.



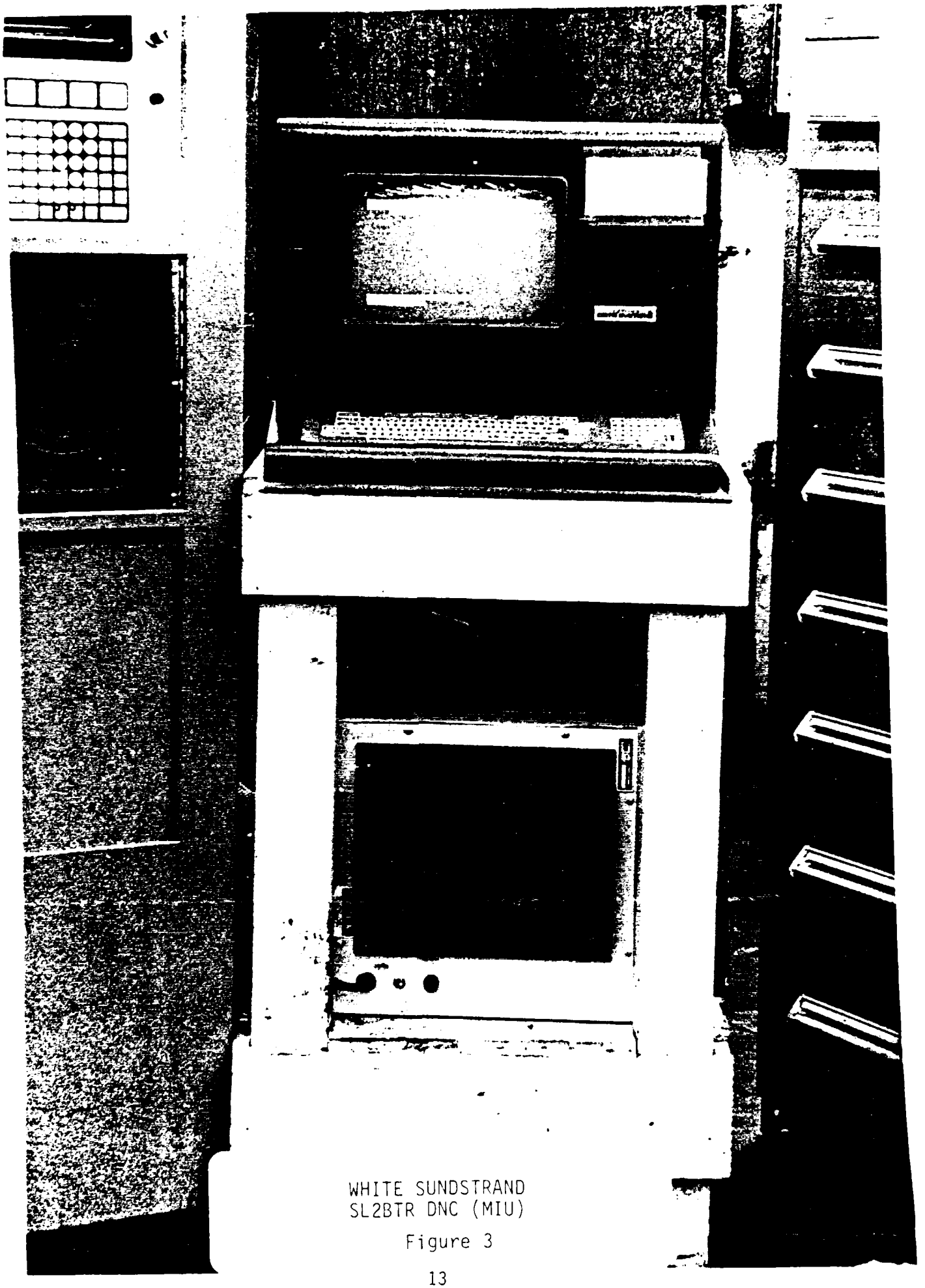
1972 K&T 5-Axis Machining Center

Figure 1



KT - GEMINI - D CNC

Figure 2



WHITE SUNDSTRAND
SL2BTR DNC (MIU)

Figure 3

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